ch 2-1

國立臺北科技大學

九十三學年度化學工程系碩士班入學考試

化工熱力學與反應工程試題

填准考證號碼

第一頁 共二頁

注意事項：

1. 本試題共五題，配分共 100 分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在答案卷之答案欄內，否則不予計分。

1. It is possible to cool liquid water below its freezing point of 273.15 K without the formation of ice if care is taken to prevent nucleation. A kilogram of subcooled liquid water at 263.15 K is contained in a well-insulated vessel. Nucleation is induced by the introduction of a small amount of dust, and a spontaneous crystallization process ensues. Find the final state of water (i.e., ice-water mixture at what temperature), and calculate the entropy change of the water, the surroundings, and the total entropy change.
   Additional information:

The heat capacity C_p=4.185 kJ $kg^{-1}K^{-1}$ for liquid water between 263.15K and 273.15K

The heat of fusion of ice at 273.15K Δh_{fusion}=334 kJ $kg^{-1}K^{-1}$ (20%)

2. Using the following data, estimate the total pressure and composition of vapor in equilibrium with a 20 mole percent ethanol (1) solution in water (2) at 75.15℃.
Data (at 75.15℃):

vapor pressure of ethanol (1) P_1^{vap}=1.006 bar

vapor pressure of water (2) P_2^{vap}=0.439 bar

$$\lim_{x_1 \to 0} \gamma_1 = \gamma_1^\infty = 1.6931$$

$$\lim_{x_2 \to 0} \gamma_2 = \gamma_2^\infty = 1.9523$$

Assume the van Laar model is appropriate for this estimation:

$$\ln \gamma_1 = \frac{\alpha}{\left[1 + \frac{\alpha x_1}{\beta x_2}\right]^2} \qquad \ln \gamma_2 = \frac{\beta}{\left[1 + \frac{\beta x_2}{\alpha x_1}\right]^2}$$

$$\ln \gamma_1^\infty = \alpha \qquad \ln \gamma_2^\infty = \beta$$

(15%)

3. One kilogram of air is heated reversibly at constant pressure from an initial state of 300K and 1 bar until its volume triples (i.e. $V_2^t = 3V_1^t$). Calculate work W, heat Q, internal energy change ΔU^t and enthalpy change ΔH^t for the process. Assume that air obeys the relation PV/T=83.14 bar cm^{3}mol^{-1}K^{-1} and that heat capacity of air, C_p=29 J mol^{-1}K^{-1}

Additional information:

Molar mass of air M_{air} = 28.8 g mol^{-1}

V is molar volume and the superscript "t" means "total". (15%)

4. (a) Consider a reaction represented by

$A + \cdots\cdots \rightarrow products$

taking place in a plug-flow reactor (PFR).

Write a mole balance (material balance) for steady state operation in a differential element of volume, dV, as a control volume, as shown in Figure 1, for A around dV.

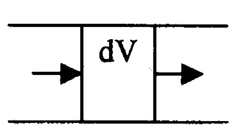

Figure 1 (10%)

(b) A liquid-phase double-replacement reaction between bromine cyanide (A) and methylamine (B) takes place in a PFR at 10℃ and 101 kPa. The reaction is first-order with respect to each reactant (i.e. $(-r_A)=k_A C_A C_B$), with $k_A=2.22\ \mathrm{L\,mol^{-1}s^{-1}}$.

If the residence time ($t = V/q_0$, q_0 is volumetric flow rate in the inlet) is 4s, and the inlet concentration of each reactant is $0.10\ \mathrm{mol\ L^{-1}}$, determine the concentration of bromine cyanide at the outlet of the reactor.

The reaction is:

$BrCN(A)+CH_3NH_2(B) \rightarrow H_2CN(C)+CH_3Br(D)$ (15%)

5. A gas-phase reaction between ethylene (A) and hydrogen (B) to produce ethane (C) is carried out in a CSTR. The feed, containing 40 mol % ethylene, 40 mol % hydrogen, and 20 mol % inert species (I), enters the reactor at a total rate (F_{T0}) of $1.5\ \mathrm{mol\ min^{-1}}$, with inlet volumetric flow rate $q_0=2.5\ \mathrm{L\,min^{-1}}$. The reaction is first-order with respect to both ethylene and hydrogen (i.e. $(-r_A)=k_A C_A C_B$), with $k_A=0.25\ \mathrm{L\,mol^{-1}min^{-1}}$.

(a) Set up a stoichiometric table for the reaction A + B→C by using feed of A, F_{A0} and fractional conversion of A, f_A. (10%)

(b) Determine the reactor volume required to produce a product that contains 60 mol% ethane.

Additional information:

The reaction is $C_2H_4(A)+H_2(B) \rightarrow C_2H_6(C)$

The designe quation for CSTR $V=\dfrac{F_{A0}f_A}{(-r_A)}$

Assume that temperature T and pressure P are unchanged. (15%)